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Dry and Wet Waste Segregation: A Comprehensive Overview of an Advanced Automatic Waste Segregation System

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ABSTRACT

In this research, waste management system is introduced to efficiently handle waste in large cities without the need for continuous manual monitoring. The system addresses the challenges take place with respect to unorganized and non-systematic waste collection by implementing an embedded Internet of Things (IoT) system that monitors individual dumpsters for deposited waste. The proposed solution includes an automated mechanism for segregating wet and dry waste, achieved through a mechanical setup that separates the waste into dedicated containers using sensors. Sensor is utilized to detect the presence of any type of waste, while a moisture sensor is employed for identifying wet waste. The system employs ultrasonic sensors at the top of each container to measure the distance, allowing for the quantification of waste volume. When one of the containers reaches its capacity, an alert message is automatically sent to the respective personnel.

Keywords: ATmega328; EEPROM; Sensors; IOREF; Waste segregation; Internet of Things; Automatic waste segregation system.

1. Introduction

Modern metropolises worldwide encounter a shared challenge in efficiently handling urban waste while maintaining cleanliness. The existing waste management systems rely heavily on a considerable workforce tasked with regularly tending to specific dumpsters on a daily basis. Unfortunately, this conventional approach results in an ineffective and untidy system, with some dumpsters overflowing while others remain scarcely filled. The inefficiency arises due to variations in population density or other unpredictable factors, making it challenging to pinpoint areas requiring immediate attention.

This paper proposes a waste management system wherein each dumpster is integrated with a monitoring system that notifies the relevant personnel when the container is full. Additionally, the system facilitates the segregation of wet and dry waste into distinct containers. By adopting this innovative approach, the proposed system gives an effective solution to the challenges associated with waste management in urban environments.

Materials like plastics and dampened paper can be subjected to recycling, turning waste into a valuable resource. By categorizing waste into different classes, effective measures can be implemented to optimize resource usage. This approach is applicable at both individual and societal levels. Waste management stands as a central concern in the modern era, with nations worldwide developing thoughts and commitments towards a healthier environment.

This study aims to implement an efficient waste management system. Currently, many cities have numerous poorly-maintained trash bins. These bins are often overflowing, with waste spilling out. People frequently dispose of trash in bins that are already full, contributing to increased pollution and an unsightly appearance in the city. This situation exacerbates air pollution and the spread of easily transmissible diseases. This study seeks to address these issues by establishing an effective waste management system, rectifying the problem of overflowing bins and promoting a cleaner and healthier urban environment.

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2. Literature Survey

Discussions about intelligent waste bins and systems have persisted for a considerable duration. The technologies employed in the development of these smart systems have also evolved, with Arduino Uno being a notable example. While each concept appears similar, there are nuanced differences at their core, and our proposed work aligns with this pattern. Following the integration of Arduino into various aspects part of our lives, our innovative proposal involves designing a smart waste collection system that incorporates citizen participation and data analysis for improved decision-making. This stands in contrast to traditional manual systems where employees routinely clear dumpsters.

In traditional waste management systems, employees manually clear dumpsters at regular intervals. A Smart Waste Bin for advanced waste management is proposed by [1]. This system incorporates sensors to measure both the weight and fill the level waste within the bin, utilizing Bluetooth for short-range communication. Another approach to waste management is presented by [2], where Arduino Uno is employed to monitor the trash level present in the bin and sends alerts to the city server once the bin is full. The study [3] suggests a waste management method that involves an Arduino Uno board and a GSM modem for data transmission, powered by a 12V transformer. In a similar vein, the study [4] introduces a waste management technique wherein the bin is connected to a microcontroller-based system. This system includes an IR remote system and a central framework displaying the current status of the trash bin.

3. Hardware and Software Requirements

3.1. Hardware

3.1.1. Arduino UNO

The Arduino Uno is a microcontroller which relies on the ATmega328P. It can be connected to a computer using a USB cable or powered through an AC–to–DC adapter or battery. The microcontroller at the core of the Arduino is the Microchip ATmega328P, operating at 5 volts. It has an input voltage range of 7 to 20 volts, 14 digital I/O pins (with 6 providing PWM output), 6 analog input pins, and a DC current of 20 mA per I/O pin. The DC current for the 3.3V pin will be 50 mA. The flash memory capacity is 32 KB, with 0.5 KB used by the bootloader. The Arduino Uno also has 2 KB of SRAM and 1 KB of EEPROM, operating at a clock speed of 16 MHz. Its physical dimensions include a length of 68.6 mm, a width of 53.4 mm, and a weight of 25 g. It includes all the necessary components for supporting the microcontroller, requiring only a connection to a computer via USB or power from an AC-to-DC adapter or battery. Notably, the Uno distinguishes itself from previous boards by using the Atmega16U2 also defined as (Atmega8U2 up to revision R2) reconfigured as a USB-to-serial device, eliminating the need for the FTDI USB to the serial driver chip

3.1.2. Ultrasonic Sensor

An ultrasonic sensor is affixed to the front side of the waste container to continuously monitor the level of trash inside. The ultrasonic sensor employed in this system is a 4-pin module, with the pins named Vcc, Trigger, Echo, and Ground. This versatile sensor is commonly used in applications requiring distance measurement or object

detection. The module features two components resembling eyes on the front, akin to a robot, constituting the ultrasonic transmitter and receiver. The transmitter emits a supersonic wave into the air, and when this wave encounters any material, it reflects back toward the sensor. The ultrasonic receiver module detects this reflected wave, as depicted in the image below.

3.1.3. Moisture Sensor

Moisture sensors are designed to assess the volumetric water content present in soil. Unlike the direct gravimetric method, which involves removing, drying, and weighting a soil sample, these sensors indirectly measure water content by utilizing other soil properties like electrical resistance, dielectric constant or interaction with neutrons as indicators of moisture content. The correlation between the measured property level and soil moisture requires calibration and may vary based on environmental factors like soil type, temperature, or electric conductivity.

Remote sensing on hydrology and agriculture utilizes the impact of soil moisture on reflected microwave radiation. Farmers or gardeners can employ portable probe instruments to gauge soil moisture levels. The moisture sensor determines the amount of waste subtracting the dry waste from the initial waste, and the moisture present in it is then calculated as the amount of waste which was divided by the dry waste or total weight, present on the chosen reporting method.

3.1.4. Servo Motor

A servo motor was a precision motor capable of rotating with high accuracy. Typically, it depends on control circuit that gives a feedback on current position on the motor shaft, enabling precise rotation. Servo motors are commonly used when precise rotation at specific angles or distances is required. The motor operates on servo mechanism which it is charged by mostly using DC power supply it is known as a DC servo motor; if powered by AC, it is referred to as an AC servo motor. The focus is on the working of DC servo motors. Beyond the major difference there are different types of various servo motors depends on gear arrangement and also the operating characteristics. Servo motors often incorporate a gear arrangement, allowing for a high torque output in compact. Due to these characteristics, servo motors find applications in diverse areas like toy cars, RC helicopters.

3.2. Software

3.2.1. Arduino IDE Software

The Arduino Integrated Development Environment (IDE) is compatible with Windows, and Linux, which was written in the Java programming language. Its primary function is to create and upload programs to Arduino-compatible boards, and it extends support to other vendor development boards with the help of third-party extensions. The Arduino IDE is designed to work with the C and C++ languages, utilizing specific code formatting conventions. It incorporates a software library from the Writing scheme, offering a range of common input and also the output procedures. User-written code typically involves two essential functions, one for initializing the sketch and the other for the main program loop. These functions are compiled and also linked with a program into an executable cyclic executive program using the GNU toolchain, which is included in the IDE distribution. To convert the given code into a hexadecimal-encoded text file, the Arduino IDE utilizes the Arduino program. This

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file is then transferred to the Arduino board by using a loader program within the board's firmware. The primary code, referred to a sketch, produced on the IDE platform, ultimately generates a Hex File that is transferred and uploaded into the controller present on the board.

4. Methodology

Presently, waste dumping has emerged as a significant and urgent issue in our environment, posing a potential crisis for current and future generations. A variety of waste types, including perishable and recyclable materials, are indiscriminately mixed and dumped on land, resulting in substantial negative impacts. Consequently, effective waste management has become a crucial concern for the well-being of society. Notably, there is currently no established system for segregating household waste into categories such as dry and wet waste. To address this issue, an Automated Waste Segregator (AWS) can be implemented at the any household level, facilitating the direct processing of waste. However, this system has limitations, as it can segregate one type of waste at a time, with a predefined priority for wet and dry waste. To handle mixed waste types, buffer spaces can be employed. Recognizing the swift sensing capability for metal objects, the entire sensing module can be positioned along a single stable platform to enhance results. Initially, a standing model was proposed for system implementation. However, to improve accuracy, feasibility, and cost-effectiveness, a decision was made to adopt a conveyor belt system. This involves mounting various sensors on the sides of the belt to effectively segregate waste.

5. Proposed Model

The main goal of this study is to automate the efficient sorting of different types of waste. This information can significantly improve decision-making for those managing litter bins and cleaning services to ensure effective disposal. The ultrasonic sensor is tasked with object identification, and moisture sensors play a crucial role in detecting wet and metal waste. Upon identification, the waste is deposited into the bin, where the sensor categorizes its type. The bin is designed with two partitions, each dedicated to collecting a specific type of waste. Following this, the motor engages in rotation to separate the collected wastes, facilitating subsequent processing.

5.1. Proposed System

5.1.1. Block Diagram

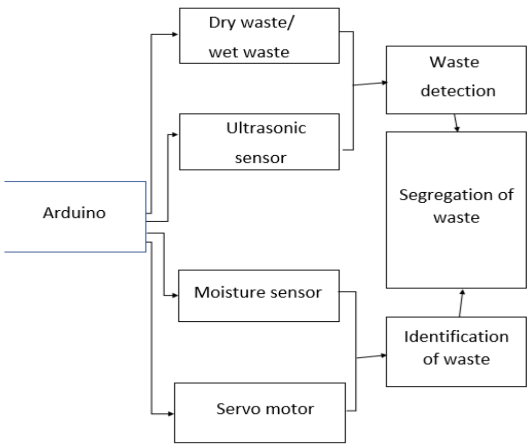

Figure 1. Block diagram of the proposed system

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5.1.2. Flowchart

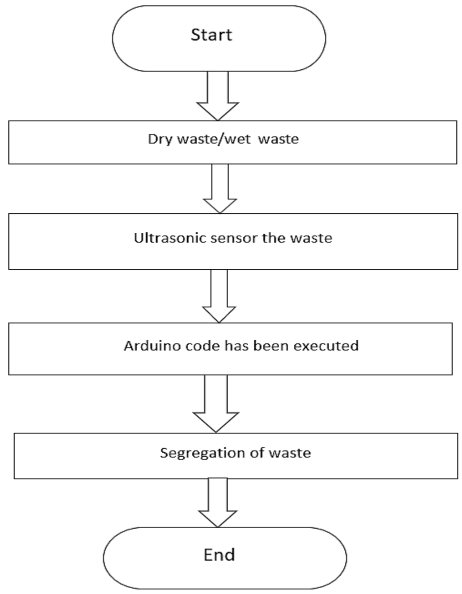

Figure 2. Flowchart of the proposed system

6. Results

Waste segregation plays a crucial role in enhancing the reuse, recycling, and recovery of waste, thereby improving the overall recycling process. The practice ensures that only degradable wastes are disposed of in the natural environment, leading to a reduction in overall pollution. The efficient use and preservation of resources for future generations are promoted through waste segregation.

Additionally, waste segregation is vital for public health, particularly in the separation of hazardous and non-hazardous waste. Health-related issues may arise when waste is discarded without proper segregation, with various illnesses linked to the presence of non-biodegradable and toxic waste.

The process involves a plank where a moisture sensor detects the wet or dry nature of an object placed on it. Based on this determination, a servo motor directs the waste into the corresponding bins. Subsequently, an ultrasonic sensor gauges the distance from the bin's surface to the garbage. When the bin reaches full capacity, a signal is sent to the Arduino Uno, which, in turn, communicates with the computer. The process pauses until the bin is emptied.

6.1. Circuit Diagram

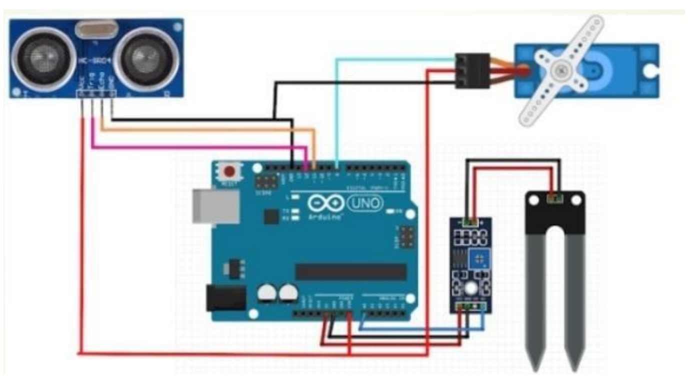

Figure 3. Hardware design of proposed solution

7. Conclusion

Introducing this system at a local level, such as in residential areas, educational institutions, etc., can alleviate the burden on local authorities. The automated waste segregator represents a small yet significant stride toward establishing an efficient and cost-effective waste collection system, minimizing human intervention and eliminating potential hazards to human life. The incorporation of a conveyor belt enhances the system's accuracy, cost efficiency, and ease of installation, making it suitable for domestic use.

The segregation of various wastes at the household level also contributes to time savings. During the implementation of our system, challenges were encountered, including issues with the sensing range of the inductive proximity sensor and the accuracy of the moisture sensor, among others. Despite these challenges, modifications were applied to enhance the system's reliability, although perfection was not entirely achieved.

The advantages of reducing human time and effort, promoting health and sanitation, protecting the environment, and ensuring cleaner garbage disposal are integral to the implementation of this system.

Declarations

Source of Funding

The study has not received any funds from any organization.

Competing Interests Statement

The authors have declared no competing interests.

Consent for Publication

The authors declare that they consented to the publication of this study.

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